uNDFom: HOW DOES IT VARY ACROSS THE FORAGE POPULATION?

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With the introduction of the CNCPS 6.5 Biology came the need for new nutrient analyses. Previous versions predicted the indigestible NDF (iNDF) as (lignin x 2.4). The iNDF is used as the end point of fiber digestion and factors into the rate of digestion calculation (kd). Recent work (Raffrenato et al., 2010) has shown that the iNDF constant of 2.4 varies across feed types, thus a better measure is needed if we are to improve our ability to predict kd.

Research at Cornell has determined that measuring rumen in vitro NDF digestibility (NDFD) at 30, 120 and 240 hours will lead to the better prediction of kd. These measures along with NDF are performed on an organic matter (om) or “ash free” basis to reduce the artificial inflation of NDF in high ash samples. High ash can overwhelm the ability of the NDF solution to solubilize all of the minerals. The residual minerals contaminate the NDF residue leading to an overestimation of the fiber value. This may lead to rations that appear to be adequate in fiber, which in fact are deficient. The resultant over estimation of fiber may lead to problems often associated with low fiber diets such as reduced feed intake, rumen acidosis, foot problems, etc..

Along with the new measures comes new terminology to define and differentiate the new from existing values. Now NDF is labeled as aNDFom indicating that it has been treated with amylase and sodium sulfite and determined on an organic matter basis. The indigestible NDF (iNDF) or end point of fiber digestion is replaced by the undigestible fiber (uNDF) as measured after a 240 hour in vitro incubation in rumen fluid. To maintain consistency of terminology and reflect that the results are on an organic matter basis, the undigestible fiber and fiber digestibility are expressed as uNDFom and NDFDom, respectively, followed by the time point, e.g., uNDFom240 & NDFDom240. This applies to all time points. Undigestible was chosen to better define the NDF remaining at any specific time point.

The Dairy One Forage Lab began offering the new organic matter values in January 2015. The following tables and figures provide insight to the variation across the population of the primary forage types. The data were collected during the period of January to July 2015. Legume and grass categories were designated based on the customer supplied description. Legume and mixed mostly legume (MML) were grouped together as legumes. Likewise, grass and mixed mostly grass (MMG) were grouped together as grass. Unless otherwise noted, all nutrient composition values are expressed on a dry matter basis as a percentage of the dry matter. NDFD values are expressed as a percentage of the aNDFom.

Table 1. shows the base nutrients for the population of samples summarized. Corn silage and legume haylage were representative of and comparable to historical averages, while the grass data was better in quality and more representative of mixed mostly grass. All populations provided a good basis for evaluating the new component analyses.

Table 1. Base nutrient values (averages) of sample population

Forage	n	CP	ADF	aNDF	Lignin	ASH	FAT
Corn Silage	5,030	8.22	26.52	44.77	3.17	4.18	3.21
Legume Silage	2,280	21.01	34.89	46.99	7.09	10.81	3.89
Grass Silage	3,959	16.37	36.85	56.36	5.91	9.42	3.96

The aNDFom provides the base measure for subsequent fiber digestibility measures. Table 2. summarizes the typical differences between aNDF and aNDFom. Across feed types the difference ranged from 0 – 21.29 percentage points with an unweighted average of 2.01.

Table 2. aNDF vs aNDFom

	Corn Silage			Legume Haylage			Grass Haylage		
	aNDF	aNDFom	diff	aNDF	aNDFom	diff	aNDF	aNDFom	diff
n	5,030	5,030	5,030	2,280	2,280	2,280	3,959	3,959	3,959
mean	44.77	42.93	**1.84**	46.99	45.14	**1.85**	56.36	54.01	**2.35**
sd	5.36	5.57	1.51	5.48	5.57	1.18	6.90	7.16	1.56
min	28.65	19.72	0.00	31.61	27.04	0.00	35.64	31.44	0.00
median	44.32	42.49	1.30	46.57	44.84	1.50	56.00	53.72	1.62
max	79.74	78.84	16.59	69.94	67.85	11.88	85.05	80.85	21.29

Tables 3., 4. and 5. provide the base data for uNDFom measures. Rates of digestion are plotted in Figure 1. comparing the average values for a forage type to the least and most digestible samples as determined by uNDFom240. The spread between these lines demonstrates the potential range within the population.

Table 3. Corn silage om digestiblities

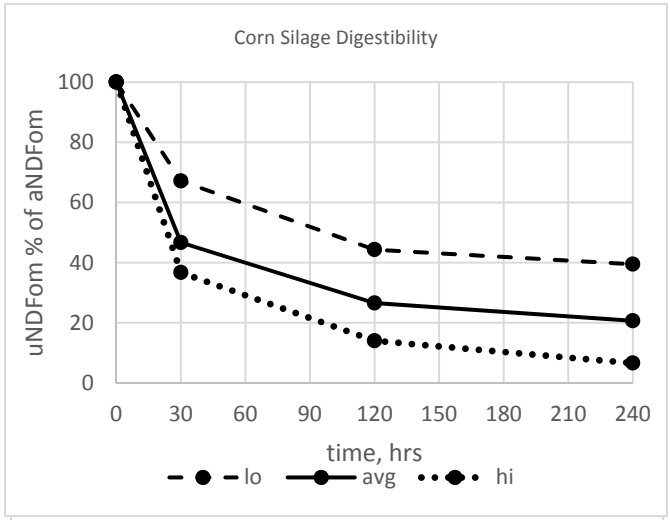
	aNDFom	uNDFom30	uNDFom120	uNDFom240	lignin x 2.4	constant	NDFDom30	NDFDom120	NDFDom240
n	5,030	5,030	5,030	5,030	5,030	5,030	5,030	5,030	5,030
mean	42.93	20.04	11.41	8.91	7.60	**2.83**	53.34	73.44	79.37
sd	5.57	3.86	2.73	2.31	1.51	0.59	6.37	5.00	3.91
min	19.72	6.27	3.34	2.06	1.18	1.04	15.22	48.70	60.36
median	42.49	19.74	11.23	8.77	7.49	2.83	53.33	73.53	79.25
max	78.84	52.62	34.73	30.95	22.90	11.03	81.58	92.29	94.85

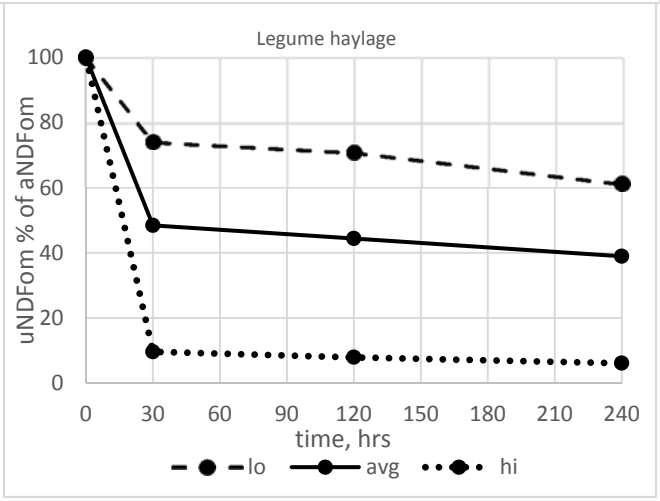
Table 4. Legume haylage om digestiblities

	aNDFom	uNDFom30	uNDFom120	uNDFom240	lignin x 2.4	constant	NDFDom30	NDFDom120	NDFDom240
n	2,280	2,280	2,280	2,280	2,280	2,280	2,280	2,280	2,280
mean	45.14	21.85	19.97	17.42	17.01	**2.46**	51.56	55.62	61.08
sd	5.57	4.93	4.56	4.31	3.40	0.40	9.14	8.94	9.44
min	27.04	3.59	2.94	2.29	1.34	1.05	10.02	27.62	37.28
median	44.84	21.59	19.75	17.40	17.11	2.45	51.46	54.75	59.89
max	67.85	47.71	42.76	36.94	31.99	6.55	90.38	92.12	93.86

Table 5. Grass haylage om digestiblities

	aNDFom	uNDFom30	uNDFom120	uNDFom240	lignin x 2.4	constant	NDFDom30	NDFDom120	NDFDom240
n	3,959	3,959	3,959	3,959	3,959	3,959	3,959	3,959	3,959
mean	54.01	23.88	19.79	14.82	14.20	**2.52**	56.43	63.70	72.67
sd	7.16	7.86	6.22	5.22	3.70	0.68	10.71	9.23	8.77
min	31.44	4.57	3.47	2.61	3.86	1.01	11.27	28.44	37.85
median	53.72	22.93	19.30	14.52	13.99	2.50	56.76	64.14	73.55
max	80.85	59.49	45.91	36.10	45.48	6.64	89.55	92.06	94.38





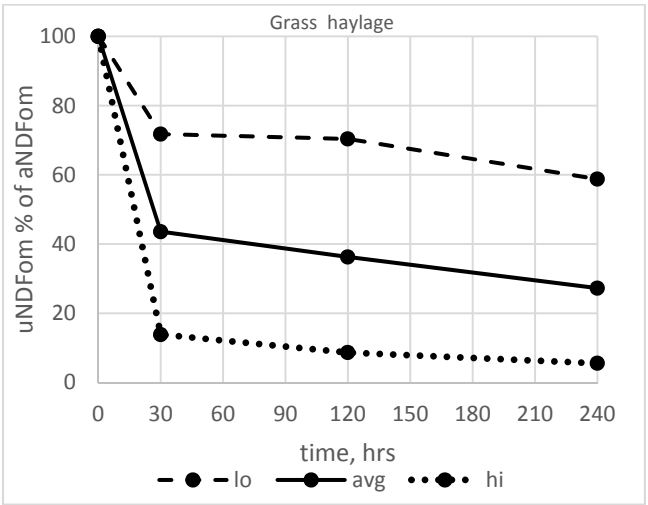


Figure 1. Rates of digestion with uNDFom expressed as a percentage of aNDFom

Tables 6. And 7. explore indigestibility and rate constants. At the heart of the new fiber measures was the desire to better define the end point of digestion and prediction of kd. Previous versions of the CNCPS model estimated this value as (lignin x 2.4). In CNCPS 6.5, the value is measured as uNDFom240. Figure 2. is from an earlier summarization of samples analyzed by our lab. These data were from a smaller population of samples (corn silage n = 1,171, legumes n = 419, grasses n = 1,083) than the current summarization and were used to bring more clarity to the graphics. There was a moderate positive relationship between iNDF and uNDFom240 across all forages, but the take home point is the wide degree of variation about the trend line illustrating the diversity of values in the population (Figure 2.). Likewise, the calculation of individual rate constants as [uNDFom240/lignin] yielded means of 2.46 and 2.52 across the haycrop populations with a combined range of 1.01 – 6.64 (Table 7.). The corn silage mean was similar at 2.83 (Table 7.), but ranged from 1.04 – 11.03 (the next highest value was 8.23).

Table 6. iNDF* vs uNDFom240

	Corn silage		Legume haylage		Grass Haylage	
	uNDFom240	iNDF	uNDFom240	iNDF	uNDFom240	iNDF
n	5,030	5,030	2,280	2,280	3,959	3,959
mean	8.91	7.60	17.42	17.01	14.82	14.20
sd	2.31	1.51	4.31	3.40	5.22	3.70
min	2.06	1.18	2.29	1.34	2.61	3.86
median	8.77	7.49	17.40	17.11	14.52	13.99
max	30.95	22.90	36.94	31.99	36.10	45.48

*iNDF = lignin x 2.4

Table 7. Indigestibility constant summary table (historic = 2.4)

Forage	n	mean	sd	min	max
Corn Silage	5,030	2.83	0.59	1.04	11.03
Legume Haylage	2,280	2.46	0.40	1.05	6.55
Grass Haylage	3,959	2.52	0.68	1.01	6.64

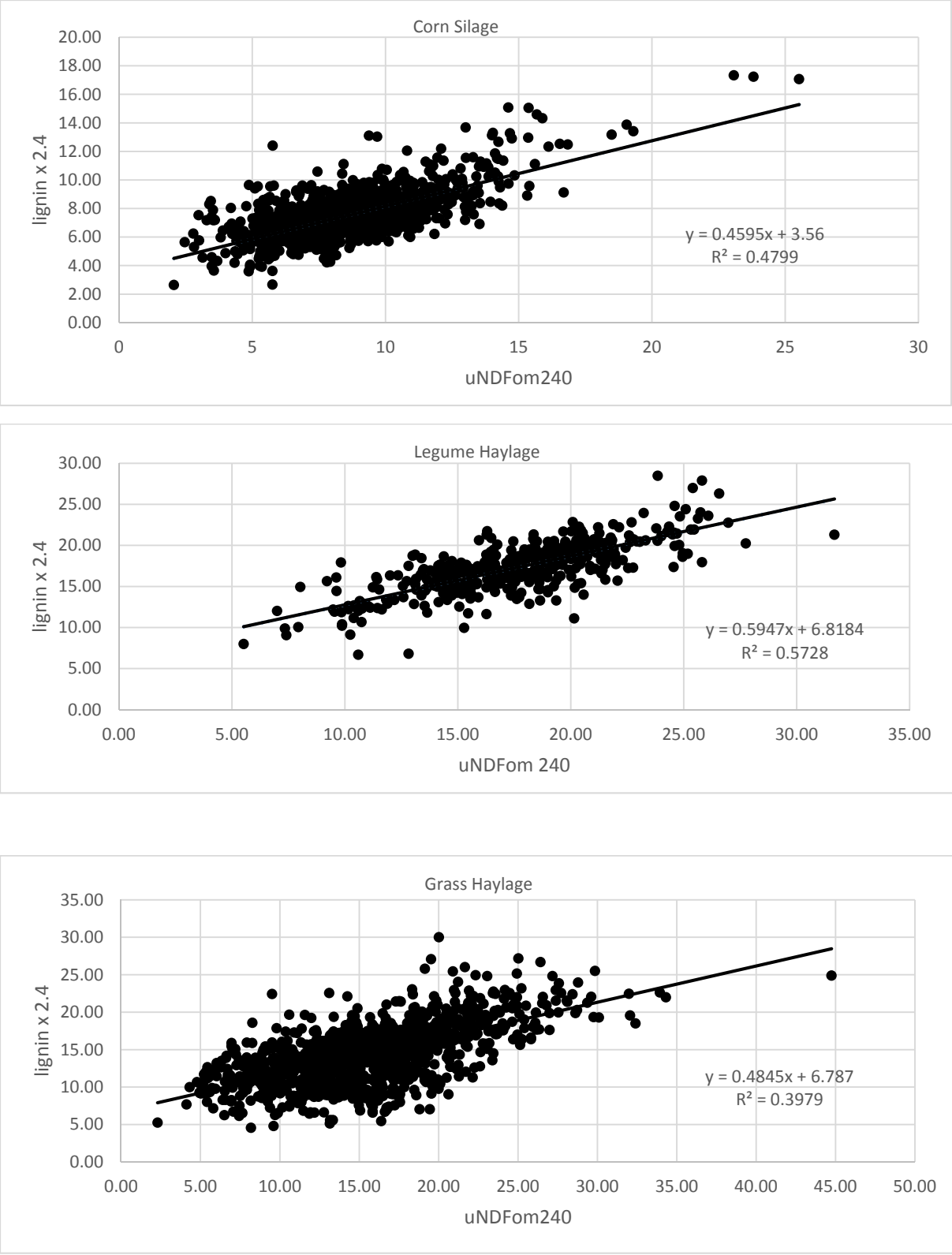


Figure 2. Lignin x 2.4 (iNDF) vs. uNDFom240

In conclusion, data collected from a large population of samples analyzed during the course of routine commercial forage analysis demonstrated sufficient variation in the determination of uNDFom240 to warrant routine analysis in favor of using fixed values in the course of rate predictions.

REFERENCES

Raffrenato, E. and M.E. Van Amburgh. 2010. Development of a mathematical model to predict sizes and rates of digestion of a fast and slow degrading pool and the indigestible fiber fraction. Proc. Cornell Nutrition Conf. p.52 – 65.